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THE HART MOUNTAIN OVERTHRUST AND ASSOCIATED STRUCTURES IN PARK COUNTY, WYOMING¹

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INTRODUCTION

Field work during the summer of 1916 brought to light what is believed to be one of the most interesting major thrusts yet described in the northern Rocky Mountains. So far as the writer is aware, the true nature of this fault has not heretofore been described, although Fisher² refers to it in discussing the structure of Hart Mountain. The area studied embraces a narrow strip of territory lying between the area covered by Fisher's Big Horn Basin report, just mentioned, and the Absaroka quadrangle on the west.

STRATIGRAPHY

The stratigraphy of the region is essentially the same as that given by Fisher in his above-mentioned paper describing the area adjacent on the east. The divisions of the Cretaceous adopted in mapping are those used by Lupton,³ since they represent more detailed work than was done by Fisher. Hewett⁴ has also described the stratigraphic column in some detail in the region immediately east of the area mapped by the writer. The following table of formations is largely compiled from the three reports mentioned above. Detailed description of the various stratigraphic units will not be given, except in the case of the so-called Fort Union(?) regarding the age of which there may be some question.

¹ Published by permission of the Wyoming State Geologist.

² C. A. Fisher, *U.S. Geol. Survey, Prof. Paper No. 53*, p. 37.

³ Lupton, "Oil and Gas near Basin, Wyoming," *U.S. Geol. Survey, Bulletin 621L*.

⁴ Hewett, "The Shoshone River Section," *U.S. Geol. Survey, Bulletin 541*, pp. 89-

Fort Union(?).—Since there is some uncertainty as to the age of the formation described under this name, and since upon this formation more than on any other depends the dating of the fault in question, it seems worth while to give a detailed description of its relations and lithologic character.

TABLE I
TABLE OF FORMATIONS

System	Formation	Characteristics	Thickness in Feet
Quaternary....		Glacial till and terrace gravels	?
Tertiary.....		Andesitic breccias and lavas	?
Cretaceous or Tertiary....	Fort Union(?)	Buff to yellow sandstones, conglomerates, red and gray shales	300+
	{ Cody.....	Gray to black shale, sandy near top	2,000
	{ Frontier.....	Gray sandstones and shales, with ben- tonite	500
Cretaceous....	{ Thermopolis and Mowry..	Gray and intensely black shales, with sandstone and bentonite	900
	{ Cloverly.....	Gray cross-bedded sandstone and shales	110
Jurassic or Cretaceous..	Morrison.....	Variegated red, gray, maroon (etc.), shale, and sandstone	500
Jurassic.....	Sundance.....	Greenish-gray shales and sandstones and thin fossiliferous limestones	500
Permo-Trias..	Chugwater....	Red sandstones and shales with gypsum	750
	{ Embar.....	Massive gray limestone	100
	{ Tensleep.....	Massive gray sandstone and brown quartzite	100
Carboniferous..	Amsden.....	Red shale and red to gray limestone	150
	{ Madison.....	Massive gray limestone, conglomeratic at the base in places	1,000
Ordovician....	Bighorn.....	Massive gray limestone	300
Cambrian.....	Deadwood....	Conglomerates, sandstone, and limestone	800
Pre-Cambrian.		Red granite, gneisses, and schists	?

It consists of an unmeasured thickness of alternating beds of yellow sandstone with red and white or gray clays. The sandstones vary from buff to bright yellow, and occur in several beds from 2 to 20 feet thick. They are cross-bedded on a large scale, and contain many concretions of brown sandstone varying from a few inches up to 10 feet or more in diameter. The concretions are harder than the matrix and weather out in large numbers, occurring abundantly over the surface of the ground. At many places the sandstones are finely conglomeratic, the pebbles averaging between one-fourth

and one-half inch in diameter. Red granite, basalt, quartzite, sandstone, black chert, brown chert, and shale make up the bulk of the pebbles. The shale members of the formation are dominantly gray, but contain many red layers. Thin lignitic seams were noted, but no leaves were found in a sufficient state of preservation to permit identification. One thin seam of black coal was found in the formation.

At one point the beds were seen to rest on the Cody with slight angular unconformity, although at several other points they partake of the folding of the older formations.

Though no fossils were found in these beds, the abundance of the red clays, the pebbly character, and the slight angular unconformity at the base all seem to favor correlation with what Hewett has called the Fort Union. It is true that Hewett has made no mention of the large concretions which are so abundant, and the writer noted similar ones from the basal Laramie of Fisher (Hewett's Gebo), not far to the east of the area mapped. At the same time similar concretions were noted, however, at a much higher horizon in Fisher's Laramie, in what is believed to represent Hewett's Fort Union. Fisher describes such concretions as occurring in the Laramie, but does not indicate the exact horizon.

Along the North Fork of Shoshone River these beds trace continuously into what Hague¹ has mapped as Pierre and Fox Hills. At the same point, however, Hewett² calls them "Tertiary sandstones and shales probably of Wasatch age." Structural reasons will be given later for believing that they are earlier than Wasatch.

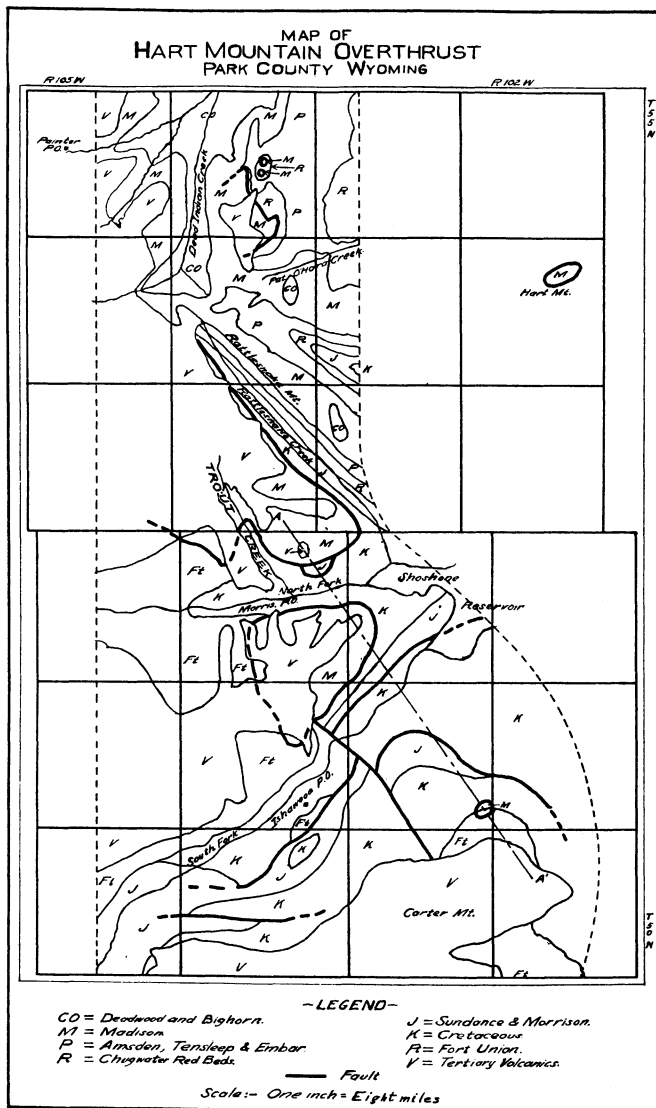
STRUCTURE

The major thrust.—The main plane of fracture occurs at or near the base of the Madison (Mississippian) limestone, which has been thrust out over beds varying in age from Madison to Fort Union(?). At the southernmost point, where the fault was located, the limestones rest on sandstones of Fort Union(?) age, but toward the north the stratigraphic throw decreases until at the northernmost

¹ Hague, Absaroka Folio, *U.S. Geol. Survey*, Folio 52.

² Hewett, "Sulphur Deposits in Park County, Wyoming," *U.S. Geol. Survey, Bulletin* 450, p. 478.

extremity the Madison rests on the Chugwater Red Beds. For the most part the Mississippian limestones are more resistant than



the beds on which they rest, and this condition results in a pronounced Madison escarpment along most of the course of the fault.

This escarpment is a very striking feature of the scenery along the Cody Road to Yellowstone Park, just west of the Shoshone Reservoir.

Traced westward up the valley the fault on either side passes beneath the Tertiary volcanics and is lost. It passes in a bold escarpment around the east end of the divide between the North and South forks of Shoshone River and extends for several miles up the north side of the latter valley, where it is again buried beneath the Tertiary breccias. It does not reappear on the south side of the valley of the South Fork except as an isolated peak of Madison resting on Fort Union(?) at the east end of Carter Mountain in Sec. 36, T. 51 N., R. 103 W. Several miles south of this point, however, abundant Madison boulders are noted along the slopes on the east and southeast of Carter Mountain, indicating that the fault block of Madison probably occurs buried beneath the lavas of that mountain, or even possibly outcropping in small overlooked exposures along the lava scarp of that divide.

On the north side of the North Fork Valley the scarp makes a sharp re-entrant where Trout Creek cuts through the faulted block. In Sec. 6, T. 52 N., R. 103 W., the scarp bends abruptly northwestward and extends for a long distance along the west side of Rattlesnake valley, overlapped at several points by Tertiary volcanics, beneath which it passes at the head of the valley. In this distance the Madison rests on successively older beds, from Cody shale to Chugwater "Red Beds." The trace of the fault could not be found on the east side of Rattlesnake valley, from which the block of faulted Madison has probably been largely removed by later erosion. It is suspected that fragments of the block still remain on the top of Rattlesnake Mountain anticline, but if so they probably rest, Madison on Madison, and have not been detected. Along the divide between Rattlesnake valley, Pat O'Harra valley, and Dead Indian valley the trace of the fault plane could not be found, either because wholly removed by erosion or because Madison was faulted on Madison and not detected. In Sec. 3, T. 54 N., R. 104 W., the fault plane again emerges from beneath a small patch of Tertiary breccia and traces easily northwestward, to the point where the wagon road crosses Dead Indian Ridge, a distance

of four or five miles. Throughout this distance the Madison rests on the Red Beds. In Sec. 22, T. 55 N., R. 104 W., two prominent hills of Chugwater are capped with isolated patches of Madison.

In Sec. 16, T. 55 N., R. 104 W., the trace of the fault plane is lost, probably because it passes wholly into the Madison, where it is not easily detected. This view is supported by the fact that the Madison in this region appears to be excessively thick, as though repeated.

Not far from the center of T. 54 N., R. 102 W., occurs an isolated peak known as Hart Mountain. It consists of a cap of several hundred feet of Madison limestone, entirely surrounded by late Cretaceous and Tertiary sediments. It has been described¹ as due to a circular fault. Because this mass of Madison is entirely isolated in outcrop, it is not possible to demonstrate the continuity of the major thrust, just described, to this point. But the supposition hardly admits of doubt that Hart Mountain constitutes a portion of the large fault block so widely exposed to the west, especially in view of the similarity of stratigraphic units involved.

The extreme irregularity shown by the fault trace is largely due to erosion, in part to later deformation, since the fault plane dips at various but low angles at various points.

The north and south extent of the fault has been proved for over 25 miles in a straight line and for more than double that distance measured along the sinuosities of its course. Exclusive of the Hart Mountain outlier the easternmost and westernmost exposures are separated by a distance of 7 miles; including Hart Mountain, by about 16 miles. At the westernmost exposure the fault passes beneath the Tertiary andesites and is lost. At this point the Madison rests on the Fort Union (?), which in turn can be traced without break at least 6 miles farther west. If the movement was from the west eastward, as will be shown later, the fault plane must pass at least this far west, hidden below the lava, but cut through by erosion before the lava was poured out. If this is the case, the amount of displacement must have been not less than 22 miles, making no allowance for recession of the eastern front by erosion. Using average figures for the thickness of the beds involved, the vertical displacement is over 6,000 feet.

¹ C. A. Fisher, *loc. cit.*

There is nothing sufficiently regular about the dip of the fault plane to indicate the direction of movement. The fact, however, that the Cretaceous and Tertiary rocks in the Bighorn Basin to the east are continuous and but slightly disturbed for nearly 100 miles indicates plainly enough that the faulted block did not come from the east. The thick cap of volcanics to the west makes it impossible to expect any evidence in that direction, but in spite of that is seems clear enough that this block moved from west to east.

The South Fork thrust.—Along the lower valley of the South Fork of Shoshone River a second thrust fault is exposed on both sides of the valley, below the Hart Mountain thrust already described. As far as this fault could be traced, Sundance was found resting on Cody or Fort Union(?), and a section from the river level to the top of the ridge on the south side of the valley reveals the following situation:

Top
 Madison
 Major thrust
 Fort Union(?)
 Cody
 Frontier
 Thermopolis and Mowry
 Cloverly
 Morrison
 Sundance
 Minor thrust
 Cody
 Bottom

On the north side the section is as follows:

Top
 Madison
 Major thrust
 Frontier
 Thermopolis and Mowry
 Cloverly
 Morrison
 Sundance
 Minor thrust
 Cody
 Bottom

This fault seems to pass wholly into Cody shales both to the north and south and cannot be traced more than 6 or 8 miles. It probably shows again, in Sec. 11, T. 52 N., R. 104 W., on the north side of the North Fork, where abundant Sundance fossils are found on Cody shale slopes, just at the base of the main Madison scarp. It has a horizontal displacement approximating 10 miles, and a vertical movement of about 3,000 feet, or nearly 10,000 feet for the two faults combined.

Near the west line of T. 51 N., R. 103 W., the trace of this fault, which lies about S. 45 W., on both sides of the valley is suddenly lost in an area of intense brecciation, which is believed to mark the site of a transverse fault. The transverse fault seems to have shifted the trace of the thrust northwest about a mile, and west of the point of disturbance the thrust can be traced only on the south side of the valley. On the north side it is probably buried beneath Tertiary lavas. It has not been possible to prove the identity of the thrust planes east and west of the transverse area of disturbance, but the similarity of stratigraphic relationships [Sundance on Cody and Fort Union(?)] seems to indicate the possibility of the foregoing explanation.

The thrust plane appears to have been sharply folded along an axis lying about northeast and southwest, parallel to the trend of the South Fork Valley. At one point where a deep gorge cuts the axis of a sharply overturned anticline, not far south of Ishowooa Post-Office, yellow sandstones are exposed in a very small area beneath typical Sundance beds. The sandstones carry no fossils, but are similar in appearance to the Fort Union(?), and if of Fort Union(?) age the exposure represents a "Window" or "Fenster," such as has been described by several writers, in connection with major thrusts elsewhere.

Beartooth fault zone.—Along the eastern edge of the Beartooth Plateau, from the Clark Fork to the Montana line, is a zone of thrust faults, probably related to the same forces producing the faults already described though not continuous with them. The southern extremity of this zone lies about 8 miles north and 4 miles east of the northernmost point to which the Hart Mountain thrust was traced. This group of faults, all of which are associated with

overturned folds, in places carries the Pre-Cambrian granite out over the "Red Beds." The fault planes could not actually be observed, but are undoubtedly much steeper than the plane of the Hart Mountain thrust. The amount of horizontal displacement was not determined.

Mechanics of the faulting.—While no theoretical discussion of the mechanics of these great faults is proposed, it seems worth while to present some observations which may ultimately help to throw light on the problem:

1. The fault contact is practically everywhere concealed by talus from the Madison cliffs, but at several places it could be located within a few feet, and the zone of crush breccia is notably thin at most points.
2. The great limestone block above the fault plane is little folded. But while it presents the general aspect of a nearly flat-lying horizon, locally the dips are high, as a result of numerous small normal faults which appear to have been the result of the settling of the great block after the thrust ceased.
3. The soft shales below the major thrust plane, while much crumpled at places, are nearly horizontal and almost undisturbed over considerable areas where exposed by erosion several hundred feet lower than the major thrust.

HISTORY

The history of the faulting in this region depends, for its correct solution, on the careful determination of the age of the beds herein called Fort Union(?) and on a knowledge of the relation of these beds to the faulted block of Madison limestone. The second part of the problem is comparatively simple, and will be discussed first.

For long distances these beds occur at the foot of the Madison scarp, and there was little question from the very first that they passed beneath the Madison block. In view, however, of the statement of Hewett that these beds are probably of Wasatch age, it was thought possible that the sandstone might have been deposited, after the faulting and erosion, against the foot of the limestone scarp, since it was nowhere possible to find an actual contact of the Madison resting directly on the Fort Union(?).

If, however, the sandstones were laid down against the base of these high cliffs, they should contain a coarse and abundant angular limestone conglomerate, whereas a careful search nowhere revealed any Madison limestone in any of the sandstone of the formation. This constitutes abundant evidence that the Fort Union(?) actually passes beneath the fault block and does not lap against its foot.

As to the second problem, the exact age and equivalence of the beds called Fort Union(?), a less definite conclusion is possible. They are younger than the Cody, upon which they rest with slight angular unconformity at places. The fact that they are involved in the major faulting and folding makes it probable that they are not Wasatch, as Hewett has suggested, since beds of that age are known to cover similar major faults in Idaho.¹ The only other formations with which it seems at all possible to correlate them are Hewett's Gebo (Fisher's basal Laramie) or Hewett's Fort Union(?) (Fisher's upper Laramie), and to the writer the evidence seems in favor of the latter conclusion. If these beds are the equivalent of Hewett's Fort Union, it still remains to determine whether they represent the equivalent of the original Fort Union and whether they are very late Cretaceous or early Tertiary, problems with which this paper has nothing to do.

These faults involving the Fort Union(?) pass at many points beneath the Andesite, which Hague, in the Absaroka Folio, has called the Early Basic Breccia and which he considers to be of early Neocene age. This would date the faulting as taking place after the sedimentation of the Fort Union(?) and before the Neocene, probably in very early Tertiary time, since following the faulting long erosion had trenched the region deeply and in places completely cut away the fault block, before the Basic Breccia was laid down.

CORRELATION WITH OTHER FAULTS

Richards and Mansfield² have presented a concise statement of the available information regarding major thrusts in the northern Rocky Mountains, and hazard a possibility that these may consti-

¹ R. W. Richards and G. R. Mansfield, "The Bannock Overthrust," *Jour. Geol.*, XX (1912), 704.

² *Op. cit.*

tute parts of one major thrust, carved into isolated portions by erosion. As they suggest, however, such correlation awaits further and more careful study, particularly as to the dating of the faults. To the information they have gathered may be added the more recent work of Haynes¹ on the "Lombard Overthrust" in Montana.

The present paper is presented as a further contribution to the subject, and, while conclusions as to correlation are still premature, the writer believes it to be quite improbable that these various faults will ultimately be found to be a part of one great overthrust. It seems much more likely that they represent numerous "Decken" or rock sheets, the one driven over the edge of the next after the manner described by Geikie² in discussions of Alpine structure. Two such rock sheets, one above the other, are exposed along the South Fork of Shoshone River, in the area here described.

¹ *Jour. Geol.*, XXIV (1916), 269.

² Geikie, *Mountains, Their Origin, Growth, and Decay*.